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Comparison study of sugarcane leaves and corn stover as a potential energy source in pyrolysis process

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Abstract

Sugarcane (*Saccharum officinarum*) and corn (*Zea mays*, Linn.) is widely planted in Thailand. The pyrolysis process has been carried out in thermochemical processing of organic decomposition of biomass to increase the value of the biomass. The aim of this study was to research the probability of sugarcane leaves and corn stover for pyrolysis process. The proximate analysis results indicate that corn stover has a volatile content higher than sugarcane leaves. Sugarcane leaves have a higher ash content than corn stover. The heating value was obtained 14.47 and 20.91 MJ/kg for sugarcane leaves and corn stover, respectively. TGA results show 4 stages: dehydration, active pyrolysis passive pyrolysis and completed combustion stage. Furthermore, the thermal degradation of biomass could be considered an optimization of temperature for pyrolysis process.

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Keywords: Pyrolysis; horizontal fixed bed reactor; char; wood vinegar

1. Introducion

Sugarcane (*Saccharum officinarum*) and corn (*Zea mays*, Linn.) is widely planted and used for industrial purposes in Thailand. Large amount of post-harvest residues are produced during harvesting of sugarcane, including

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sugarcane tops [1]. Another residue is corn stover which is the residue that is left on the soil surface after corn grain harvested. Both sugarcane Leaves and corn stover are an abundant, inexpensive and readily available source of lignocellulosic biomass [2] which are all useful raw materials for activated carbon [3]. Moreover, an agricultural waste could be a renewable energy. Currently, sugarcane leaves are used as raw materials in bioethanol product but the process require some chemical or biochemical for decomposing cellulose and hemicellulose to generate fermentable sugars. In contrast, pyrolysis process, is a thermochemical process which is able to recycle excess energy while producing lower pollutant as by-products [2]. Pyrolysis of biomass produces gas and liquid products and leaves a solid residue. The solid residue from pyrolysis process is biochar which could be used as fuel and activated carbon precursor. The liquid residue is bio-oil which consist of alcohol, aldehyde, ester and phenolic compound [4]. Moreover, the gas residue could be renewable energy as syngas. The objective of this work was to studies the thermal properties of agricultural waste for the energy conversions.

2. Materials and methods

2.1 Preparation of biomass

Sugarcane leaves and corn stover sample were collected from the northeastern of Thailand region. The samples were crushed using a blender and sieved with a 20, 32 and 35-mesh-screener (425-850 μm). The samples were dried in an oven to below 10 wt% moisture content at a temperature of 103 ± 2 ºC for 10 h.[5]

2.2 Analysis of biomass

2.2.1 The heating value of biomass analysis

The calorific value of sugarcane leaves and corn stover were found using a proximate analysis for moisture, ash and volatile matter, respectively by Bomb calorimeter (Gallenkamp, UK) [6].

2.2.2 Thermogravimetric (TGA) analysis

The thermal degradation of sugarcane leaves and corn stover were found using a Thermogravimetric analyzer (TGA 50, Shimadzu, Japan). The sample was heated in a temperature range of 30 – 600 ºC with a heating rate of 10 ºC/min under nitrogen flow.

3. Result and discussion

3.1 The proximate analysis and heating value analysis of sugarcane leaves and corn stover

Table 1 presents proximate analysis and higher heating values of sugarcane leaves and corn stover. The main components of Sugarcane leaves and corn stover were volatile content and fixed carbon.The corn stover contains 61.59 %wt volatile content while the sugarcane leaves is about 32.34 %wt. However, the fixed carbon of the sugarcane leaves is higher than that of the corn stover by 26.31wt%. The volatile content is obtained by the decomposition of hemicellulose and cellulose which could be changed to bio-oil [7]. The fixed carbon is obtained by lignin degradation. The fixed carbon is known as biochar which could be used in fuel application as substitutes for coal [8]. Sugarcane leaves have a higher ash content than corn stover. This could be decreased the liquid fraction in pyrolysis process[9]. Furthermore, the heating value was obtained 14.47 and 20.91 MJ/kg for sugarcane leaves and corn stover, respectively. The heating value is indicated to the amount of carbon source in biomass : the higher carbon source gave a higher yield of pyrolysis products [10].

Table 1. the Proximate analysis (wt%, dry basis) and higher heating values ((HHV in kJ/kg, dry basis) of sugarcane leaves and corn stover

Properties	Sugarcane leaves	Corn stover
Moisture content	6.61	8.39
Volatile content	32.34	61.59
Fixed carbon	54.57	28.26
Ash content	6.48	1.77
Higher heating value	14.73	20.91

3.2 Thermogravimetric analysis (TGA) of sugarcane leaves and corn stover

Thermogravimetric analysis (TGA) of sugarcane leaves and corn stover are shown in Fig.1a and b, respectively. Fig.1a and Fig.1b show similar trend which illustrate the thermal degradation in 4 stages. The first stage is a dehydration stage of materials in a temperature range of 35 to 190 ºC and 30 to 205 ºC for sugarcane leaves and corn stover. In this stage the moisture in biomass was removed with a small decreasing of weight loss[11]. The second stage is an active pyrolysis at about 190 to 350 ºC for sugarcane leaves and 205 to 340 ºC for corn stover. During this stage, initiation of carbonization was observed and the mass loss at the end of the stage was approximately 45 and 30 %wt for sugarcane leaves and corn stover. The mass loss was mainly volatile matter and tars [12] . The third stage is a passive pyrolysis in the range of 350 to 540 ºC and 340 to 485 ºC for sugarcane leaves and corn stover which the mass loss was from lignin and fixed carbon [13]. Finally, at the final stage, at the temperature above 540 and 485 ºC for sugarcane leaves and corn stover, the complete combustion was occurred with the ash content of about 8 and 3 %wt. The corn stover was decomposed to be ash at a lower temperature than sugarcane leaves. This could be explained by the different quantity of cellulose and hemicelluloe in biomass [14]. In this research, it was found that the corn stove was obtained a low ash contents than sugarcane leaves which a low residue ash has been reported to the high yield of bio-oil [15]. Furthermore, the thermal degradation of biomass could be considered an optimize temperature for increasing economic value process [16].

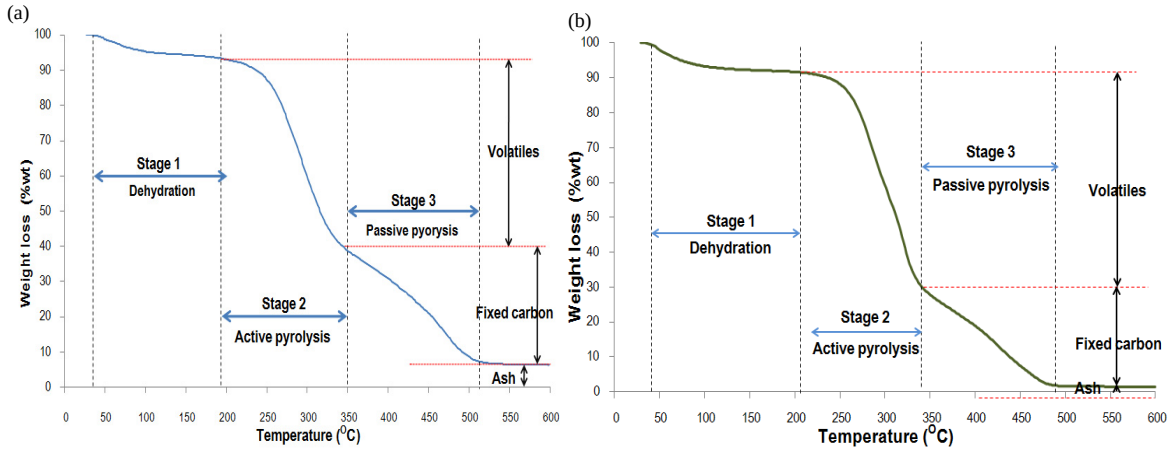

Fig 1. The thermogravimetric analysis of (a) sugarcane leaves and (b) corn stover.

4. Conclusions

In this work, the proximate analysis is indicated that corn stover has a trend to high pyrolysis product due to the abundance of volatile content and low content of ash. TGA of sugarcane leaves and corn stover are show 4 stage of heating decomposition which consist of dehydration, active pyrolysis, passive pyrolysis stage and completed combustion. The corn stover was showed lower thermal degradation than sugarcane leaves and this require a low enegy consumption in pyrolysis process. Moreover, the thermal properties of corn stover and sugarcane leaves in this paper seem to be the adaptability in the energy conversions. Extensive research would be investigate an efficiency of conversion by corn stover and sugarcane leaves.

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